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Vikström, Peter

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**Long term Patterns in Swedish Growth
and Structural Change, 1870-1990**

Research Memorandum GD-48

Peter Vikström

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Long-term Patterns in Swedish Growth and Structural Change, 1870-1990

by

Peter Vikström, Dept of Economic History, Umeå University, Sweden*

Abstract

The aim of this paper is to examine long-term patterns in growth and structural change in the Swedish economic development between 1870 and 1990. The analysis is based on a systematic quantitative analysis that previously has not been applied to the Swedish economic performance. The analysis includes an explicit measure of the rate of structural change and a time series analysis based on structural time series models. This methodology makes it possible to examine long-term trends of the growth and structural change process.

The results of the analysis reveal that the Swedish long-term economic performance between 1870 and 1990 can be divided into four sub periods, with important changes occurring in the early 1920s and the late 1960s. The results are then contrasted with two perspectives on long-term economic performance. The first is the periodisation based on alternating periods of structural change and structural rationalisation that is specific for Swedish economic-historical research. The second perspective focuses on the role of technological shifts that lead to changes in the growth performance, making it possible to identify growth periods or growth regimes. The empirical results of the analysis of the Swedish development lend support to the growth regime approach, but as the analysis is based on highly aggregated data, it is not possible at this stage to reject one approach in favour of the other.

* Dept of Economic History, Umeå University, S-901 87 UMEÅ; e-mail:

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1. Introduction

The growth performance of different countries have for a long time been of primary interest for both economists and economic historians. Especially during the aftermath of the slowdown in growth that occurred in the 1970s, the debate was intensified on issues concerning growth performance and the driving forces behind the growth slowdown. In the long-term perspective, questions concerning economic growth are often related to questions concerning structural changes in the economy. Structural change is seen as an indispensable part of the growth process and a precondition for sustained growth, as changes in technology and market conditions call for structural changes to ensure an efficient resource allocation.

The aim of this paper is to examine the long-term pattern in growth and structural change in Sweden, using methods that previously have not been applied in a systematic way to these issues in Swedish economic historical research. In order to get a good picture of the long-term pattern, the data is analysed within a consistent framework of structural time series models.

The results are discussed in the context of two previously suggested patterns of periodisation. The first one is a periodisation that during the latest decades has been put forward as a generalisation of the Swedish long-term economic performance. It builds on the presence of periods with two phases characterised by structural transformation and structural rationalisation, respectively. The second one is an interpretation that has been more widely applied internationally and it uses the concept of growth regimes that mainly are determined by shift in technological regimes. The key features of these two periodisations will be discussed further in the next section of the paper. The purpose of comparing the empirical evidence with two kinds of periodisations is not to reject one in favour for another, but to shed more light on the long-term pattern of growth and structural change in Sweden. It will be possible, though, to make some statements on the consistency of these theories with the empirical evidence for the Swedish development.

Growth and structural change will be examined on two levels in the economy. First, the development on the GDP level will be examined, which means GDP growth and structural change on the major sector level. Second, the development on the industrial sector is examined, which means growth of value added in industry and structural change between industrial branches. The data is collected from the Swedish historical national accounts and the data is discussed in section 3. The time period covered in this paper is 1870-1990. By using data for both the total economy and for the industrial sector, it will be possible to get indications on the relationship between growth on the industry level and overall growth.

The paper is organised as follows. In section 2 the two approaches for periodisation is described and their key features are compared and discussed. The data used in this investigation is described in section 3. Section 4 discusses two major methodological tools that are of key importance for the results in this paper. The first is how to define and measure the rate of structural change and the second is of to make a proper trend analysis of the time series. The main results are presented and described in section 5. Finally, the results are contrasted in the concluding discussion in section 6 to the two periodisation schemes discussed in section 2.

2. Structural periodisation and growth regimes

The most influential periodisation of the Swedish economic history has its theoretical and methodological foundation in the works of the Swedish economist Johan Åkerman (1939,1944). His work was further developed and applied by, among others, well known economists like Erik Dahmén and Ingvar Svennilson. With influences from scholars like Schumpeter and Gerschenkron, parts of Åkerman's theoretical framework evolved into the structure analytic research tradition in Swedish economic history (Pålsson-Syll, 1997).

In the 1970s and 1980s, a periodisation of the Swedish economic development was developed, first in Krantz and Nilsson (1975), and further in Krantz and Schön (1983) and Schön (1990,1993,1994, 2000a, 2000b). The periodisation, in this paper referred to as the structural periodisation, is based on the idea that the long-term economic development in Sweden can be divided into long periods with a length of 40 to 50 years, where severe structural crises mark the division between different periods. Each long period is further divided into two sub periods with different characteristics. The first sub period is a *transformation* period, where the industrial structure changes and resources are reallocated between industries. This period is also characterised by diffusion of basic innovations within the industry. The second sub period is characterised by *rationalisation*, where resources are concentrated to the most productive units and measures are taken to increase the efficiency in the production (Schön 2000b, p184). Based on this typology, the identified structural crises that mark the division between the major periods are around 1845, 1895, 1930 and 1975. Technological change plays a major role as a driving force behind the shift between periods. Basic innovations, such as steam or electricity, form the core of development blocks (Dahmén, 1988), which form the new technology and create the incentives for the renewal of the industrial structure. The development block also contains ingredients that eventually lead to inertia in the economy and the outbreak of a new structural crisis at the end of the rationalisation period.

As the periodisation is based on differences in the pattern of structural change, the predictions about the long-term growth development is more implicit. Productivity growth is seen to be lower during the transformation, as transformation is a time consuming process and resource demanding, which hampers productivity growth. In the rationalisation period, the previous investments in transformation pay off and it is possible to identify larger effects on productivity and growth (Schön 2000b, p193). Thus, there is a trade off between investment in transformation and growth in the short run.

The empirical evidence for the presence of these periods is, in the tradition of structural analysis, based on a number of structural indicators. Among the most important is the investment ratio, the export ratio, and structural indices for labour and energy use that are based on a shift-share analysis. It is worth noting that there are no indicators that are aimed at directly measuring the main characteristics of the two sub periods, based on their definition. For instance, there are no indicators that measure the degree of reallocation within the industry or that measure the amount of concentration within branches. The measure of structural change that is used in this paper and that is described in detail in section 4, is a step towards measuring the reallocation directly.

A contrasting view on the periodisation of long-term growth is the existence of growth regimes that has been put forward for the growth performance of the Netherlands. In a recent article concerning the Dutch growth pattern during the 19th and 20th centuries, the Dutch growth history has been divided into three growth phases or regimes. (Smits, de Jong and van Ark, 1999). Here the 19th century has been characterised by a rather low and steady growth. During the 20th century, growth accelerated and sustained at a high level until the 1970s. From the 1970s, growth rates declined to the level of the 19th century. These characteristics have also been demonstrated by van Zanden (2000), where the slow growth of the 19th century is characterised as equilibrium growth. The higher growth between 1920 and 1970 is characterised as a transition or growth along a disequilibrium path. The characterisation of the different periods is based on three indicators: GDP growth, the investment ratio and the wage share. Depending on the development of these indicators, the periods are characterised as equilibrium or disequilibrium growth periods. There exists (yet) no exact definition of what constitutes a growth regime, and in this paper an instrumental definition will be used. Following the definition in van Zanden (2000, p85), a growth regime is an extended period in which economic growth shows more or less stable characteristics. This means that shifts in growth regimes should be visible in the growth series used here, even if it is not possible to assess the existence of growth regimes based on this evidence alone.

In the discussion concerning the causes behind the shift in growth regimes and their characteristics, technological factors are of primary interest. The shift from stagnating growth in the 19th century to higher growth in the 20th century is driven by the transfer to a technological regime where electricity replaces steam as the major power source and invention. The acceleration of growth due to the shift in technology is explained by that electricity is easier to apply in different industries than steam and therefore contributes to a general increase in the productivity growth. Steam power is harder to apply in many industries and therefore contributes less to an increase in productivity growth. The shift in growth regime around 1970 can be seen as a new shift in technology to the use of information and communication technology (ICT). Paradoxically, ICT resembles the steam technology in so far that it is more selective in its application than electricity, which partly can explain the slow down in growth after 1970 (Smits, de Jong and van Ark, 1999, pp16-17).

The existence of a long period of high and sustained growth between 1920 and 1970 can also be related to the arguments by Gordon (2000) for the existence of 'one big wave' in the US development. He points to a long wave of high productivity growth between 1913 and 1970 in the growth pattern of the US. Gordon argues that it is not the slowdown after 1970 that needs to be explained, but why growth rates were so high in the period 1913 to 1970. According to Gordon, the slowdown after 1970 is a return to a more normal growth path, resembling the pre-1913 period.

The main causes behind the big wave are again technological factors. A main cluster of inventions drives the sustained growth during the big wave, where electricity plays a prominent role. Around 1970, this cluster is fully diffused and cannot longer be the engine of growth. The new inventions that emerge in the 1970s are not as important and influential as the preceding cluster and therefore the growth rate is declining.

There are a number of differences and similarities between the two approaches for separating different periods in the long-term economic development. One obvious difference is that the structural periodisation focuses on structural change explicitly defined as reallocation of resource between branches, while the growth regime periodisation focus on growth and productivity as a tool for separating different periods in the development. Even if structural change also is important in the growth regime approach, it is, however, treated in a more implicit way.

There are also large differences in the methodological and theoretical starting point used in the two approaches. The growth regime approach is more oriented to a standard economic framework than the structural periodisation. The structural periodisation is more historically oriented and utilises a broader set of indicators that are not all derived from standard economic theory. The growth regime methodology is firmly based on growth accounting investigations, where different economic growth models are central. Another basic difference between the two approaches is that in the structural periodisation, the different periods share some recurring characteristics, while in the growth regime approach, each period has unique characteristics. The structural periodisation is therefore closer to a theory of long waves in the economic development than the growth regime approach.

The most striking similarity is the important role that is given to changes in technology. Both approaches emphasise the importance of basic innovations and their effect on the performance of the economy. The structural periodisation is clearly influenced by Schumpeterian thoughts, even though both approaches share the view that technological change is an –uneven process over time. However, the growth regimes approach emphasises the productivity effects of technological change within an economic framework, while the effect of technological change on structure is more emphasised in the structural periodisation.

Considering the data used for the empirical analyses of the two approaches, both approaches rely heavily on data that exist within the national accounting framework. The major difference is that the structural periodisation relies more on data on the expenditure side, while the growth regime approach use more heavily data on factor input and production. However, as both approaches uses quantitative data that are contained within the same framework, it is clearly appropriate to explore these two approaches in the same empirical context.

3. Data

The SHNA have, compared to other countries, a long history. In the 1930s, the first estimations of the long-term development of the national income were completed. They spanned over the years 1861 to 1930 and covered production values and value added for the total economy, as well as a subdivision on seven sectors (Lindahl et al, 1937). This first version of SHNA has formed the basis for the following elaborations of the SHNA, for instance, the sector division of the latest SHNA is almost the same as in the first version.

The latest version of the Swedish HNA emanates from a project that started in the late 1970s, where the results have been published in a number of volumes. A summary of the methods used and estimates of the main aggregates can be found in Krantz (1995). Complete revisions

of the earlier estimates were done and the time period was extended to cover the years 1800 to 1980. Much effort was also done to calculate new deflators of the Paasche type in order to obtain reliable constant price estimates of the Laspeyres type. The sector division of the current HNA is based on the one in the first project and is shown in table 1 below.

Table 1. Sector division of the latest SHNA.

Sector	Description
I	Agriculture with ancillaries
II	Industry and handicrafts
III	Building and construction
IV	Private service production
V	Services of dwellings
VI	Transport and communication
VII	Public services production

Source: Krantz (1994).

In addition to the main sectors, there are a varying number of sub sectors or branches corresponding to each main sector. In general there is a production account for each sub sector, showing production values, intermediate consumption and value added. Through aggregation, it is then possible to obtain production accounts for the main sectors and the total economy. The subdivision for the industrial sector is shown in table 2 below.

The industrial sector is divided into 9 branches, which largely is dictated by the branch division in the Swedish industrial statistics and the division that was used in the previous generations of the SHNA. One major drawback with this branch division is that branch 1, mining and metal industries, becomes unproportionately large compared to the other branches. This makes it harder to examine structural changes, as there is the risk that important structural changes are hidden due to the aggregation level.

Table 2. The subdivision of the industrial sector.

Branch
1. Mining and metal industries
2. Stone, clay and glass industries
3. Wood products industry
4. Paper and printing industries
5. Food processing industries
6. Textile and clothing industries
7. Leather, hair and rubber industries
8. Chemical industries
9. Power stations, gasworks and water-works

Source: Krantz (1994).

The state of the SHNA makes the suitable for extensions that cover more than the production side. One obvious choice is to extend the SHNA with income accounts according to the guidelines in the latest System of National Accounts (1993) (SNA-93). The first phase of this work has recently been concluded and is published in Vikström (2000). This implementation contains generation of income accounts for the seven main sectors and the nine industrial branches and covers the years 1870-1990. The remaining income accounts, which describe the

distribution and redistribution of income among institutional sectors, cover the time period 1905 to 1970. At the present, it has not been possible to create consistent series for the whole period 1905 to 1990 due to inconsistencies and changes in the revisions and estimates for the income accounts made by Statistics Sweden. The new set of data contained in the income accounts has not been fully explored yet, and in this paper only some references will be made to the functional income distribution between wages and gross profits in the industry sector.

The other data that will be used in the analysis of the long-term patterns of growth and structural change consists of data on GDP and value added in the industrial sector. GDP and value added in industry are measured in constant prices and the series are collected from Krantz (1995). For the measures of structural change, sectoral shares are calculated based on series in current prices. The main reason behind using shares calculated in current prices is the additivity problem that occurs due to the deflation method used in the SHNA. The deflators in the SHNA are calculated by linking Paasche deflators for sub periods. When the deflators for the sub periods are linked, the resulting volume estimates loses their additivity, i. e. the sum of the sector shares does not add to unity. This means the structure measured at constant prices is hard to interpret and loses intertemporal comparability, as the error is not constant over the whole time period. The series in current prices for the calculations of the sectoral shares are collected from Krantz (1995) and Schön (1988), extended with data from the official national accounts for Sweden.

4. Method

In this section, two important parts of the methodology used for the analysis in this paper are discussed. As they have not been applied widely in economic-historical analysis, it is appropriate to discuss them in detail. In the first part of this section, different methods for measuring structural change and an aggregate measure for the rate of structural change is suggested. In the second part issues concerning analysis of long-term trends are discussed, where it is argued that the framework of structural time series models is a suitable tool for the analyses performed in this paper.

4.1 Measuring structural change

Definitions and concepts

In both the Swedish periodisation and in the discussion concerning growth regimes, structural change is of vital importance. In the Swedish periodisation, structural change is the explicit characteristic that identifies the different periods. In the growth regimes, structural change is an important consequence of the changes in technology and shift between technological regimes. However, even if structural change is recognised as an important concept, there exists a number of perspectives on what structural change really is, and thus structural change needs to be defined.

The concept of “structure” can be defined “as the system of relations, which prevails between the parts of a unit” (Hjalmarsson, 1973) Thus, structure and structural change may pertain to

different levels of aggregation in the economy, from firms to branches to the whole economy. In operationable terms, Hjalmarsson saw the structure as the relation between two input coefficients and the unit production capacity. A prerequisite for using this approach is proper input-output tables for enabling Leontief decomposition, something that is rare when investigating historical issues.

A similar definition is put forward by Chenery et al (1986), where structural transformation is defined as the set of changes in the composition of demand, trade, production and factor use that takes place as per capita income increases. Also here Leontief decomposition seems to be suitable for empirical investigations. A definition that is very similar is used by Blomqvist (1989), who defines structural change as the changes that take place over time in the composition of production and the allocation of production factors. While Chenery et al see structural change as a function of economic growth, Blomqvist sees it as a function of time. Of course, time can only be a proxy for changes in other factors.

In the two periodisation approaches discussed in this paper, structural changes primarily deals with changes in the allocation of resources and thus changes in the composition of production. The definition of structural change that will be used here will be changes in the composition of value added for the entity whose structure is investigated.

The next step is then to determine a suitable way to measure the changes in structure. Structural change, as it is defined here, consists of two parts; a magnitude and a direction. Technological shifts imply that reallocation occurs in favour of “new” or high productive sectors on the expense of “old” or low productive sectors. It is also possible that shift in technology does not lead to major structural shifts if the new technology can be applied equally well in all branches, which probably is the case with the innovation of electricity. Furthermore, as technological shifts are not continuous processes over time, it can be expected that the magnitude of structural change vary over time, depending on the timing and applicability of the technology or set of innovations that are introduced.

The Swedish periodisation is more explicit when it comes to the role of the magnitude dimension of structural change. The transformation period is a period where the industrial structure changes through reallocation, where the rationalization period is characterized by concentration of resources to the most efficient units. (Schön, 2000b, p184). However, these concepts and the changes in industrial structure is never operationalized and measured directly, so it is difficult to understand exactly how the magnitude of structural change differs between the two periods. It is possible that the concentration of resources to more efficient units also leads to increasing rates of structural change, as measured as changes in the composition of output. Thus, Schön’s concepts of transformation and rationalization lack somewhat the ability to predict differences in empirical observations concerning the changes in the composition of output.

The standard method of measuring structural change is to measure the changes of separate sectors’ shares in total output. However, this provides only information on the magnitude and direction of structural changes that is attributable to these individual sectors. It gives no information of the overall magnitude of structural change. Therefore, in order to complement the measures of structural change relating to individual sectors, it is desirable to obtain a

measure of the overall rate of structural change, especially if structural change is examined on a fairly disaggregated level. This is comparable to the procedure when you use the mean and standard deviation to describe a population and not only data for each individual.

As in the case of mean or standard deviation, a single measure of the magnitude of structural change means that the dimension of the underlying data is reduced, and that information is lost under way. However, the lack of details can often be an asset, especially when the broad patterns are investigated.

A measure of structural change

A one-dimensional measure of the magnitude of structural change can be defined in many ways. A simple and intuitive measure that can be used to capture the total magnitude of the structural change between two points in time is to use the changes of each sector's share in the total output. If the absolute values of the changes of each sectoral share are added we get a measure that is large when the changes in sectoral shares are large, or in other words when the structural change is large. This intuitive measure is defined as:

$$c_t = \sum_{i=1}^n |s_{i,t} - s_{i,t-1}| \quad (1)$$

where $s_{i,t}$ are sector i 's share in total output at time t and n is the number of sectors. Another measure that is closely related to this measure is to use the standard deviation of the changes of the sectoral shares.

Another approach is to compare the growth rate in each sector with the overall growth rate. The idea is that structural change implies differences in growth rates between different sectors. Roman (1969) has used this measure as an indicator of structural change:

$$V = \frac{1}{n} \sum_{i=1}^n \left| \frac{1+r_i}{1+\bar{r}} - 1 \right| \quad (2)$$

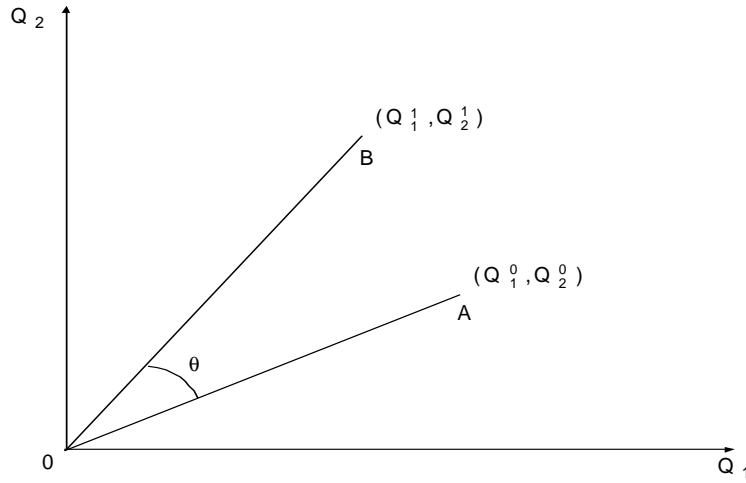
where r_i is the growth rate for sector i and \bar{r} is the average growth rate for the sectors.

These measures, however simple, have a number of theoretical shortcomings that renders them less usable as indicators of structural change. Moore (1978) discusses the theoretical properties of these measures and points out that they have a weak link to theories of economic growth and the index numbers that are used to measure growth. These measures are not invariant to homogenous growth in the elements in the output bundle and are therefore not independent of changes in the overall growth rate unaccompanied by structural change.

It is the approach used in Moore (1978) that will be used in this paper to analyse the pattern of structural change in Sweden. Moore's measure of structural change is based on the fact that the structure of output can be described as a vector whose coordinates are the quantities of output. The angle between two vectors measured at different points in time is then a measure

of structural change. The principle for this measure is illustrated for the two-commodity or – sector case in figure 1 below.

Figure 1. The principle for the angle measure of structural change



In the figure, the vector 0A describes the composition or structure at the starting point and the vector 0B describes the structure at the ending point. The angle θ is then a measure of the extent of structural change between the starting and the end point. The two-commodity case can easily be extended to an arbitrarily number of commodities, using a vector in n-space. The measure used in this paper is based on sectoral shares. Furthermore, Moore shows that the vector coordinates can consist of sectoral shares as well as commodities in physical or monetary values. Using sectoral shares and following Moore's definition, the angle θ is defined as:

$$\cos \theta = \frac{\sum_{i=1}^n s_{i,t} s_{i,t-1}}{\left(\sum_{i=1}^n s_{i,t}^2 \right)^{1/2} \left(\sum_{i=1}^n s_{i,t-1}^2 \right)^{1/2}} \quad (3)$$

The measure of structural change using θ can be measured in two ways, either as the change form year to year or as the change relative a specific comparison year. The year to year measure give a picture of the short term dynamics of the structural change process, but it can me misleading when it concerns the long-term dynamics. It is not certain that high year to year changes imply permanent changes in the structure. A large change in one year can be balanced by a large change next year in the opposite direction, even if it is plausible that a period with sustained high year to year changes also implies a high level of permanent structural change.

The alternative approach is to compare the structure of each year with the structure of a comparison year, which raises the question on how to choose a suitable comparison year. It can directly be stated that the comparison year should be chosen as the first or final year of the investigated period. Due to the definition of the measure, the angle θ cannot have negative values, which means that if the comparison year is chosen in the middle of the time period, the resulting series will have a V shape and be hard to analyse. In the period before the

comparison year, the slope of the series is negative, as the structure is approaching the structure in the comparison year. From the comparison year, the slope of the series is positive, as the structure is departing from the comparison year structure. In addition, the comparison approach can also be used for studying the differences in structure between countries, as it has been used in Timmer and Szirmai (1999).

From the perspective of most investigations, it will be most suitable to use the first year of the investigated period as the comparison year, as the structural change process is studied as the transition from one state to another. For instance, in the process of industrialisation it is the transformation from an agricultural to an industrial economy that is of interest. There is one pitfall, though, to be aware of even when the first year is used as a comparison year, that is, that if the structure is not strictly changing from one structure to another, the resulting series is not increasing all the time. During those sub periods where the structure is reverting towards the initial structure, the series will slope negatively. While providing important information on the structural change process, it will be harder to analyse such a series statistically to get easily interpretable results on the magnitude of structural change. One remedy in such a case is to divide the total time period into sub periods, where the structure is strictly changing away from the structure of the comparison year.

In this investigation, the structural change will be measured with 1870 as a comparison year. The slope or growth rate of this series gives a measure of the rate of structural change. A steeper slope implies a higher rate of structural changes. This property makes it suitable to use time series analysis to examine the long-term patterns in the rate of structural change. The choice of 1870 as the start year of the investigated period and as the comparison year is justified by that the period around 1870 can be seen as the beginning of the major industrialisation in Sweden. From this point in time, it can be expected that the structural change process develop relatively strict as a transformation from one state to another. This expectation is, as will be shown in section 5, confirmed by the empirical estimates.

4.2 Trend analysis

The definition and operationalisation of the measure for structural change means that it is the growth rates of the time series for the structural change indicator that is of interest. Together with the growth rates for GDP and industry value added, they will form the long-term pattern of growth and structural change. The question is then: How are the growth rates best measured so that they reveal the underlying long-term changes in growth and structure?

The interest of this paper on the long-term patterns makes it obvious that it is the trend of the time series that is of interest, and to examine when and how the growth rates of the trend changes. The trend growth can be measured in many ways, and each method has its advantages and disadvantages.

One basic method of examining growth patterns that has been widely applied is to calculate average growth rates for different sub periods. The sub periods are chosen based on other evidence or qualitative knowledge. A common variation of this procedure is to use estimates of linear trends for the sub periods as estimates of the long-term growth rates within the sub periods. A more sophisticated approach is to determine the periodisation endogenously in the

mode that is used to estimate the growth rates. Two examples of this approach is Smits, de Jong and van Ark (1999), where chow tests are used to determine the shifts in growth rates and Ben-David and Papell (1998), who uses a model based on segmented linear trends.

However, both these approaches can be questioned when regarding the perspective and approach used in this paper. In the investigation in this paper, it is the long-term movement that is of interest and they must be separated from, from this perspective, less interesting short-term movements. The changes in growth due to business cycles or to short term effects from exogenous shocks must be separated from the underlying growth pattern. It is the underlying trend growth that is most appropriate to relate to changes in technology, institutions or other factors of economic-historical interest. This means that average annual growth rates are inappropriate and that some kind of trend extraction must be made.

The simple linear trend, where the series of interest is regressed on time, has a number of shortcomings. First, a linear trend may not be consistent with the economical-historical perspective, where a linear deterministic trend implies some kind of steady growth path and that the series only temporarily deviates from this path. Exogenous shocks have only a temporary impact on growth. Second, the use of linear trends is often contradictory to the stochastic properties of macroeconomic series and applying deterministic trends in this case can lead to spurious cyclical behaviour of the detrended series and incorrect inferences on the parameters of the model (Nelson and Kang, 1981; Nelson and Kang, 1984). The use of segmented linear trends, as in Ben-David and Papell (1998), can also be questioned. This approach is unnecessary complicated and the results are sensitive to the methods used to estimate the trend breaks (Harvey and Jaeger, 1993, p244).

A solution to the problem is to use the framework of structural time series models based on unobservable components, as it is formulated in Harvey (1989). These models have also been applied in economic-historical analyses of long-term growth, see for instance Crafts et al (1989, 1990).

The basic idea is that the observed time series can be decomposed into a number of unobservable components that are given stochastic properties and then estimated, by reformulating the models in state-space form and the applying an iterative procedure known as the Kalman filter. The most commonly used decomposition, which also is used in this paper, is the familiar decomposition of the time series into a trend, cyclical and irregular (residual) component.

The possibility to give the components stochastic properties is especially attractive when the analysis covers such long time period as in this case. It would be erroneous to assume that the trend for instance would have a deterministic behaviour over more than one hundred years. Moreover, the formulation of the trend that is used here also allows the estimation of not only the trend itself, but also the slope component or the rate of change of the trend. The slope component is an important tool for describing the changes in the trend and makes it easier to compare the behaviour of two or more trend components. Thus, it will be the slope component that will be the main component when the pattern of growth is examined.

The basic formulation of the model is:

$$Y = T + C + I \quad (4)$$

Where Y is the observed time series and C is the cyclical component. The irregular component I can be considered to be the residual or unexplained component of the time series. It is assumed to have the normal stochastic properties of a residual.

The trend component is regarded as consisting of two parts, i. e. a level and a slope:

$$\begin{aligned} \mu_t &= \mu_{t-1} + \beta_{t-1} + \eta_t \\ \beta_t &= \beta_{t-1} + \zeta_t \end{aligned} \quad (5)$$

where μ_t is the level and β_t is the slope. The η_t and ζ_t are disturbances that give the trend its stochastic properties. The disturbances are assumed to have zero mean and constant variances. If the variance of both disturbances is set to zero then (5) reduces to a deterministic linear trend with slope β . If the variance of ζ_t is zero then (5) reduces to a random walk with drift. Finally, if the variance of η_t is zero and the variance of ζ_t is positive, then (5) is known as a smooth or integrated trend (Harvey and Jaeger, 1993, Harvey and Nyblom, 1999). In order to examine the change of the basic long-term movements of the series, it will be the smooth trend model that is used, if it not violates the stochastic properties of the series used for the analysis (Harvey, 2000, p3).

As the slope is the component of main interest for the comparison, it must be emphasised the slope measures the *change* of the trend. A positive value of slope indicates an upward sloping trend, a rising value of the slope component indicates an accelerating growth rate, i. e. a steeper slope of the trend. It should also be noted that the growth rates that are indicated by the slope components are the growth of the slow-moving trend, which differs from year-to-year growth rates of the raw series, due to business cycles and other short-term effects. From an economic-historical perspective, the goal is often to capture the slow-moving underlying forces of growth that could be related to other basic and slow moving forces as technological change and institutions. When investigating the long-term economic performance, it is exactly the slow moving factors that are of interest, which makes this kind of trend analysis a suitable tool to assess the existence of growth pattern and the general pattern of long-term growth.

The cyclical component is defined, in line with Harvey (1989) as a combination of sine/cosine components:

$$\begin{aligned} \psi_t &= \rho(\psi_{t-1} \cos \lambda_c + \psi_{t-1}^* \sin \lambda_c) + \omega_t \\ \psi_t^* &= \rho(-\psi_{t-1} \sin \lambda_c + \psi_{t-1}^* \cos \lambda_c) + \omega_t^* \end{aligned} \quad (6)$$

where ω_t is a stochastic disturbance, similar to those discussed previously. Alternatively, the cyclical component could be defined as an AR(2) process as used in Watson (1986) and Crafts et al (1990). The trend and cyclical component can then be estimated using a suitable software package, here the STAMP package has been used (Koopman et al, 2000).

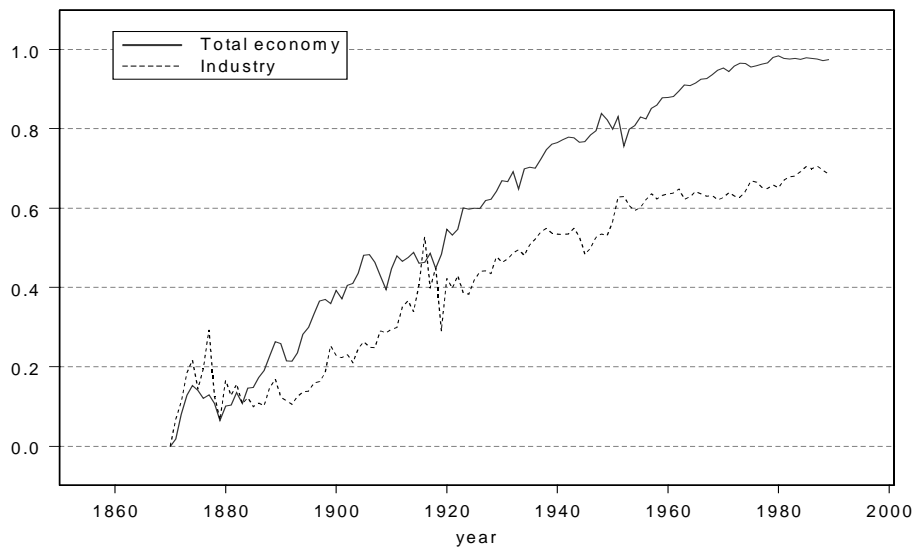
5. Results

This section contains the empirical results, which is obtained by applying the methodology outlined in the previous section to the data in the Swedish HNA. This section discusses only some aspects of the results, as the results and their interpretation is discussed more in detail in section 6.

5.1 Growth and structural change

The angle measure for structural change in, using 1870 as the base year is shown in diagram 1 below. The measure for the total economy is based on seven sectors and the measure for the industry is based on nine branches. It is possible that the branch division for the industrial sector conceals some structural change, but estimates for the period after 1950 in Lindmark and Vikström(2001) based on 20 branches reveal a similar development as the measure based on 9 branches. Before 1950, the aggregation problem is less severe as branch 1 (mining and metal industries) does not have such a dominant share as after 1950.

Diagram 1. Structural change in total economy and the industry 1870-1990



Source: Own estimates based on Krantz(1995), Schön(1988) and the National accounts.

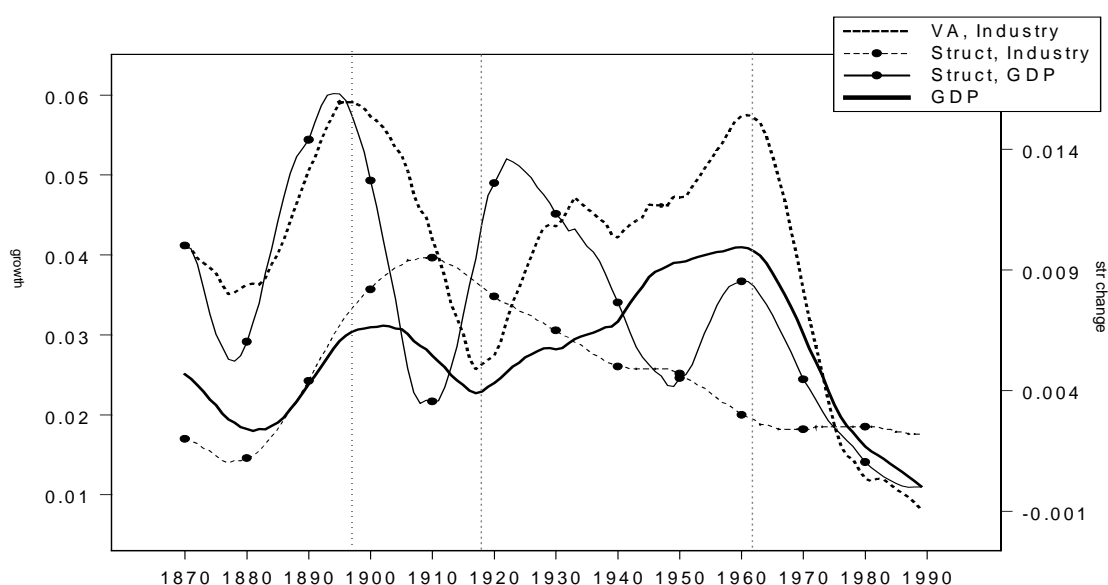
Note: The Y-axis is the angle θ , measured in radians, between the structure vector at time t and the comparison year 1870.

By eye, it is possible to spot both similarities and differences between the structural change in the total economy and within industry. Structural change spurts in both cases during the 1880s, where the structure for the total economy changes more rapidly than the industrial structure. During the interwar period, the pace slows down and increases after WWII. After 1960, the structure seems to reach a steady state, a development that is most clearly seen for the industrial sector. The positive slope of the graphs, apart from short-term fluctuations,

indicates that 1870 is a suitable comparison year, where the structure changes in one direction. Thus, the slope of these graphs will give an accurate measure of the rate of structural change. The question is how this “eye-ball” econometric analysis stands when a proper slope component for the trend is estimated and compared to the corresponding slope for GDP and industry value added.

The structural model framework as discussed in the previous section is applied on the four series; GDP, value added in industry, structural change in the total economy and structural change in industry, yielding the estimates of the slope component that is shown in diagram 2 below.¹ Remember, the slope component that is shown in the diagram measures the *change* of the trend. A positive value of slope indicates an upward sloping trend, a rising value of the slope component indicates the accelerating growth rate, i.e. a steeper slope of the trend.

Diagram 2. Estimated slope of growth and structural change in GDP and industry value added 1870-1990.



Source: own estimates based on Krantz(1995), Schön(1988) and the Swedish national accounts.

Note: VA, Industry=Slope for industry value added, GDP=Slope for GDP, Struct, Industry=Slope for structural change measure for industry, Struct, GDP=Slope for structural change measure for total economy.

Based on the slope components shown in diagram 3, it is possible to divide the time period 1870-1990 into 4 sub periods:

1. 1870-1895. The rate of structural change and growth is increasing, both for the industry and GDP. This could be seen as the presence of reallocation gains, where growth is to a large extent achieved by structural change. The reallocation gains could be a result of productivity differences between sectors.

2. 1895-1920. The rate of growth and structural change for GDP is decreasing. For the industry, the growth rate is decreasing, while structural change is still increasing up to a peak

¹ Details on the estimated models can be found in appendix 1.

around 1910. This development indicates that further growth cannot be sustained by reallocation between sectors.

3. 1920-1960. The growth rate for both industry and GDP is increasing. Due to the fact that the growth rate in industry is higher than in GDP, the rate of structural change increases for the total economy. During this period the rate of structural change in GDP is to a large extent correlated with the growth rate in the industrial sector. Overall, the rate of structural change in GDP is declining. For the industry sector, the rate of structural change is unambiguously declining, signalling that the increase in growth rates are not the results of reallocation gains, but of increased productivity and efficiency within all branches. This could be the result of a more balanced technological development between branches, where the use of electricity is a good candidate as an innovation that is easy to apply within all industrial branches. This approach to the role is similar to the view of technological change as either a “mushroom” (selective) or “yeast” (general) –process put forward in Harberger (1998).

4. 1960-1990. The growth rate is decreasing both in industry and GDP. The rate of structural change is continuously decreasing for GDP, while it reaches a rather steady level for the industry. In the beginning of the 1970s, the growth rate of the industry is for the first time below the growth rate for GDP, which indicates that the industrial sector no longer is the primary engine of growth in the economy.

Thus, the application of structural time series models makes it possible to make some generalisations about the long-term pattern of growth and structural change in Sweden. The development of each series reveals regularities or long swings, but it is not evident that they should be interpreted as cyclical regularities in the long-term development. When an analysis is made, based on the joint behaviour of these indicators, the more proper conclusion is that we are dealing with a specific historical process.

6. Growth, structural change and periodisation

6.1 Growth regimes or structural periods?

From the long-term pattern of growth presented in diagram 1, it is possible to make a periodisation based on the development of the indicators, both on their individual development and on their co-variation with each other. This periodisation reveals no regularities that unconditionally suit the 20 and 40-year periods that have been identified in the structural periodisation. On the contrary, it seems more likely that the indicators of long-term growth and structural change describe the Swedish historical process of transformation and growth from the beginning of the industrialisation to a mature and industrialised economy. The distinguished periods have unique characteristics and cannot be treated as recurring periods that share common characteristics.

The growth pattern for the industrial sector has some turning points that fit the structural periodisation, but there are also some changes in the growth trend that contradict the structural periodisation. The growth rate for the industry changes over time with peaks around 1895, 1930, and 1960 and with troughs around 1920, 1940-45, and 1980. The peak around 1895

corresponds to the structural crisis and the declining growth rate between 1895 and 1920 is consistent with the existence of a transformation period 1895 to 1920. Equally, the rising growth rate between 1920 and the first half of the 1930s is consistent with the properties of a rationalisation period. But after 1930 the growth pattern in the industry does no longer match the structural periodisation.

The pattern of structural change does not either seem to fit the structural periodisation, as the rate of structural change reaches a single peak around 1920. However, from the definitions of transformation and rationalisation, it is not perfectly clear what the structural change process should look like, when it is measured as the changes in the composition of value added. The concentration process during the rationalisation period is likely to also imply changes in the composition of output. The relatively crude measure that has been applied in this investigation must be complemented with other investigations of the production and market structure before a decisive pattern of structural change can be determined.

The growth pattern is largely in line with the growth regime approach and the results resembles those obtained for the Netherlands, as shown in van Zanden (2000) and the comparison of Swedish and Dutch long-term growth in Vikström (2001). The question is if the same explanations concerning shifts in technological regimes that have been put forward for the Netherlands are valid for the Swedish growth performance? The similarities in the timing of the changes in growth rates speaks in favour of a technological explanation, as the diffusion of innovations is likely to affect these two countries approximately simultaneously.

However, it is not clear how the structural change process is related to changes between different basic technologies. One hypothesis is that a technological regime affects productivity differently in different sectors and industrial branches, depending on variations in the possibility and ability to apply a certain technology in different sectors and branches. For instance, the steam technology of the 19th century is easier to apply in large scale and capital intensive branches, like the steel and wood industries than in small scale industries like the food processing industry. The result is an unbalanced productivity development between different branches and sectors. On the other hand, the shift to electricity as the main power source is easier to apply even in small-scale industries, and the productivity development should be more balanced between sectors and branches. This could to some extent explain the positive correlation between growth and structural change in the late 19th century and the negative correlation during the growth period 1920 to the mid 1960s.

The observed shift in technology to an ICT-based technology should then, depending on its impact on the productivity growth, also affect the rate of structural change. If, as stated earlier, the ICT-technology is more unbalanced in its impact on productivity growth, then the rate of structural change should increase, if its measured on an appropriate level of aggregation.

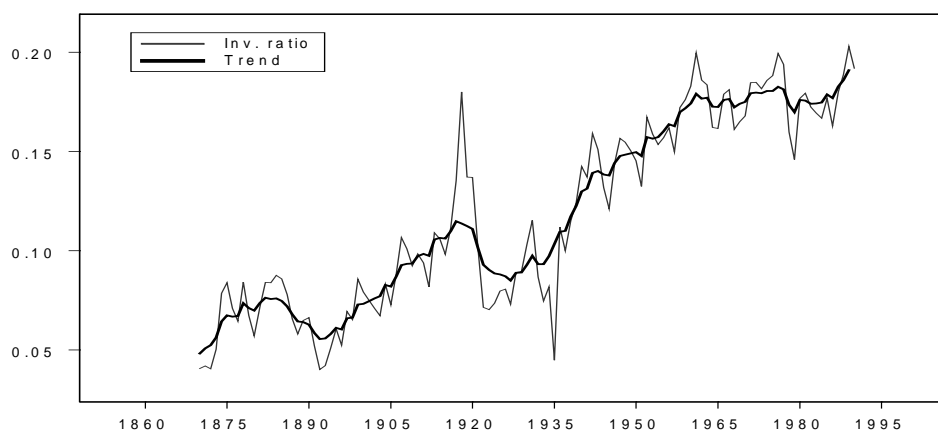
6.2 The investment ratio and functional income distribution

One common denominator of the growth regime and structural approach is the use of the investment ratio in the industry sector as an indicator for identifying different periods. According to van Zanden (2000), a sharp increase in the investment ratio, together with changes in the functional income distribution, is a sign of disequilibrium or transitory growth. In the structural periodisation, the troughs in the long cycles of the investment ratio indicate the structural crisis with the shift from a rationalisation period to a new transformation period. Therefore it is interesting and important to relate the development of this indicator to the other empirical evidence presented in this paper.

The investment ratio that will be examined is the ratio between investments and value added in industry, measured in current prices. The rationale behind using current prices is that the investment ratio is an indicator on the expenditure side and it reflects the spending decisions of the actors in the economy, whether they save or consume if their income. A ratio calculated at fixed prices does not accurately reflect the investment ratio as the result of an economic decision. In addition, if the investment ratio were calculated in fixed prices, the additivity problem would also be present. The structural periodisation uses the investment ratio at fixed prices (Schön 2000b, p182), but the long-term development of the investment ratios is similar between the series in current prices and the one in fixed prices. It is primarily for the period after 1960 that the two series differ, where the ratio in fixed prices decline, while the ratio in current prices remains at practically a constant level.

In diagram 3 below, the investment ratio for the industry sector is shown. The trend line is the trend estimated by a structural time series model, according to the approach outlined in section 4.2. Due to the stochastic properties of the series, it has not been possible to estimate a stochastic slope component in line with the other models used. Instead the best model is a random walk trend plus a stochastic cycle. In the model, the extreme values at 1918 and 1935 are treated as outliers.

Diagram 3. The investment ratio in the industry, 1870-1990, current prices.

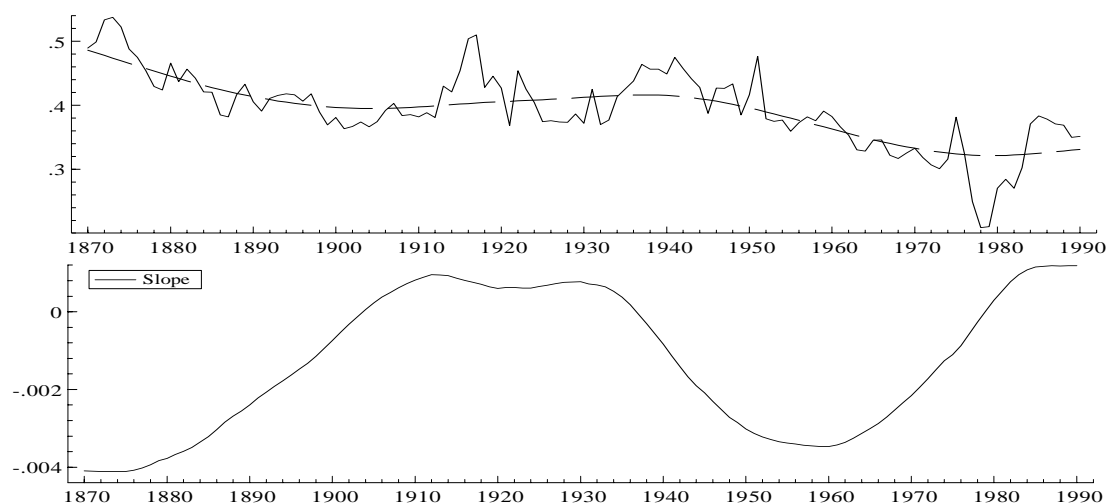


Source: The Swedish historical national accounts, National accounts and Krantz (1995).

In the structural periodisation, the turning points of the investment ratio in the middle of the 1890s, the beginning of the 1930s and the late 1970s (which is more pronounced in the investment ratio at fixed prices) mark the shifts between periods. However, the estimated trend suggests a pattern, where there are two spurts in the investment ratio. The first spurt occurs between 1890 and world war I, and the second between the mid-1930s and the beginning of the 1960s. After 1960, the investment ratio remains at a steady level around 18%.

Another stylised fact in both the analysis by van Zanden and the structural periodisation is the functional income distribution, measured as the distribution between wages and gross profits. In diagram 4 below, the gross profit share (GPS) in industrial value added is shown. The estimated trend and slope is obtained from a structural time series model.

Diagram 4. Gross profit share for the industry, 1870-1990



Source: Krantz(1995) and Vikström (2000).

The spurt in the investment ratio beginning in the 1890s coincides both with higher growth rates, increased structural change and a change in the functional income distribution. Between 1920 and the beginning of the 1930s, the investment ratio declines and remains at a lower level, while growth first is declining and then starts to increase from the 1920s and the GPS remains at a steady level. From around 1930 to the beginning of the 1960s, the investment ratio increases rapidly, growth remains at a high level with a peak in the early sixties. The GPS starts to decline, with increasing rate until the 1960s. In the beginning of the 1960s, the growth rates decline and the investment ratio stabilises. The trend of the GPS is declining more slowly and starts to increase around 1980.

Thus, the long-term, spurts in the industrial investment ratio is accompanied by increasing growth rates. The first spurt before WWI is related to increased rates of structural change, while the second spurt in growth and increased investments is accompanied by declining rates of structural change. Both spurts are related to declining trends in the GPS, of which the decline during the second spurt is more pronounced. The declining gross profit share is an indication of that the profit opportunities that results from increasing investments in high

productivity branches gradually is exploited. The declining GPS also indicates an increasing transformation pressure in the economy, which encourages improvement of the efficiency in production or rationalisation according to the structural periodisation approach.

Together, the growth rates, the investment ratio and the GPS resembles the typology of based on stylised facts in van Zanden (2000), in so far that changes in growth rates, investments and gross profits are related to each other. Thus, the Swedish long-term economic performance since 1870 shows two periods of transitory growth, i.e. 1880 to the beginning of the 20th century and from 1920 to the late 1960s. The first period seems to be a typical industrialisation period, as growth is accompanied by high rates of structural change. The second period is probably more linked to major technological changes, where the diffusion of the basic innovation of electricity is central.

6.3 Concluding remarks

The aim of this paper was to examine the long-term pattern of growth and structural change in Sweden between 1870 and 1990, using a systematic framework of structural time series models. The rate of structural change was measured directly using a specially designed measure based on vector algebra. The result of the analysis was a set of stylised facts where the long-term development could be divided into four periods.

The empirical evidence that has been put forward does not correspond clearly to the 20 and 40 year periods that form the structural periodisation approach. Instead, the growth pattern has been more in line with the results found for the Netherlands using the approach of growth regimes and the shift from equilibrium to disequilibrium growth. This conclusion is further supported by the development of the functional income distribution and investment ratio in the industrial sector.

However, this should not be interpreted as a rejection of the structural periodisation approach. The structural periodisation approach is built on extensive qualitative and quantitative research on the Swedish economic history, and covers a larger part of the functioning of the economy than can be assessed by simple growth indicators. The theoretical and empirical foundation is also different from the more economic growth accounting approach used in identifying growth regimes. The structural periodisation has no explicit aim to investigate and explain patterns in long-term growth on the aggregated level, even though it is possible to derive some predictions concerning the growth performance from the theoretical framework of the structural periodisation.

The consistency between the empirical evidence and the growth regime approach means that the use of the growth regime approach can improve the knowledge on the long-term Swedish economic performance. Two of the problems of the growth regime approach could be resolved if the theory and methodology behind the structural periodisation approach was considered when applying the growth regimes approach. First, the structural periodisation approach is explicit on the role of structural change in the long-term development. Any theoretical approach that is applied on long-term economical processes should be able to explain the role of changes in economic structure. This is important in a wider economic-historical context, as changes in the economic structure affects the society outside the strict

economic sphere, such as the political structure and living conditions for different groups in the population. Second, the concept of growth regimes needs a bit of clarification if it is to be used as an explanatory tool. Growth regimes cannot only be reduced solely to trend breaks in growth curves, but they must be more clearly linked to underlying economic and social factors. In this case, the theoretical foundation of the structural analysis approach, dating back to Åkerman and Dahmén, can be of help. The approach of using a set of structural indicators that cover different aspect of the historical development to identify structurally homogenous periods, can be a step forward relating the growth accounting approach to underlying structural factors.

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Appendix 1 – Model details

The tables below contain the estimated parameters and measures of goodness-of-fit for the models used in this paper.

Model	σ_ε	σ_η	σ_ζ	β	σ_ω	ρ	λ (period)
GDP	0	0	0.00271	N/A	0.000738	0.808	0.260 (24.1)
GDP-Struct	0	0	0.00102	N/A	0.0177	0.800	0.281 (22.4)
Industry - VA	0	0	0.00669	N/A	0.0342	0.869	0.489 (12.4)
Industry - Struct	0	0	0.00107	N/A	0.0217 *)	0.670	N/A
GPS – Industry	0	0	0.000874	N/A	0.0206	0.794	0.264 (23.7)
Investm. ratio	0	0.00665	0	0	0.0093	0.685	0.552 (11.3)

Model	R_D^2	R^2	Box-Ljung Q	Durbin-Watson	Outliers
GDP	0.125	0.999	6.95 (0.225)	1.976	1918, 1921
GDP-Struct	0.256	0.998	4.37 (0.497)	1.87	1878, 1919, 1931, 1951
Industry - VA	0.267	0.999	15.2 (0.01)	1.77	1871, 1921, 1940
Industry - Struct	0.667	0.987	8.32 (0.31)	2.00	1873, 1876, 1878, 1915, 1918
GPS – Industry	0.414	0.843	9.53 (0.09)	1.842	1915-1921
Investm. ratio	0.356	0.928	4.615 (0.465)	1.870	1918, 1935

Note: R_D^2 is a measure of goodness of fit, the measure the percentage increase of the ability of the estimated model compared to a random walk model to explain the variation in the dependent variable. A $R_D^2=0.3$ means that the estimated model explains 30% more of the variation compared to a simple random walk model. This measure is more valid than the normal R^2 when dealing with structural time series models and non-stationary time series.

The Box-Ljung Q is a test statistic for testing for autocorrelations in the residuals. The null hypothesis is no autocorrelation and the value between parentheses is the p-value of the test.

*) The cycle component for Industry-Struct reduces to an AR(1) component and it is the standard deviation and rho coefficient for this component that is shown in the table.

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